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Executive Summary

In order to address the needs of tomorrow's National Airspace System (NAS) users, the Federal Government is implementing the Next Generation Air Transportation System (NextGen). The success of NextGen will rely, in part, on the ability to provide the right information to the users that need it, when they need it. NextGen is implementing a net-centric environment to ensure that relevant, accurate, timely, and well-understood information is available to any authorized consumer and irrelevant information is filtered out. The ability to precisely direct information to users is accomplished through the use of ontologies and semantic technologies. An ontology is a set of terms, arranged hierarchically, that represent the real world objects and processes within a given domain (e.g., weather, surveillance, and safety) that has been encoded in a formal, machine-readable language. Within the context of information sharing, the ontology is used to more precisely define the meaning of an organization's data elements and attributes. The ontology provides the basis for a semantic search capability that goes well beyond simple keyword searches to searches that take into consideration the meanings of the search term (e.g. a search for "dog" should find items that contain the word "canine" since they mean the same thing). Ontologies are a key to effective information sharing across multiple communities with varying terminologies and operational needs.

This document describes the approach used by the Joint Planning and Development Office (JPDO) Net-Centric Operations Division (NCOD) in sponsoring the development of ontologies and encouraging ontology implementation in support of Net-Centric information exchanges. This approach uses small, agile development teams, called Community of Interest[1] (COI) Engagement Teams, to create an inter-organizational environment that is efficient, sustainable, and extensible. This document outlines a typical NCOD engagement with a COI or Working Group (WG) and defines a set of products that result from a typical engagement.

This document has been composed to reflect the actual approach and processes that worked for the COI Engagement Teams during engagements with the Weather and Integrated Surveillance communities. As a result, this document is based upon the actual experiences of the teams.

The *NextGen Net-Centric Concept of Operations*[2] articulates the need for interoperable systems to implement NextGen. This *Community of Interest (COI) Engagement Plan* is intended to build on these documents as well as the *AF COI Primer V1.0*[3] and the *Concept of Operations for the*

[1] DOD Directive 8320.2 defines a Community of Interest as "A collaborative group of people that must exchange information in pursuit of its shared goals, interests, missions, or business processes and therefore must have a shared vocabulary for the information it exchanges." A COI does not need to be chartered or formally structured to be considered a COI.
[2] Next Generation Air Transportation System (NextGen) Net-Centric Concept of Operations V0.7 December 2009
[3] US Air Force Community of Interest Primer Version 1.0, dated 12 July 2011

NextGen Air Transportation System[4]. Key tenets of the NCOD approach to improving interoperability include:

- **Identifying and analyzing an organization's core information exchanges.** Core information exchanges are real-world or planned exchanges between entities (such as persons, aircraft, and systems). The information being exchanged may deal with real-world events (such as flights, security incidents and weather phenomena) that play essential roles in the organization's operations, or may deal with planned events (such as flight schedule information and flight plans). Note that core information exchanges should include both actual information exchanges in place today and information exchanges required, or reasonably expected to be required, based on the NextGen architecture, the Joint Planning Environment (JPE), implementation roadmaps, and other planning documents. This will require the COI participants (both permanent and adjunct members) to be fully knowledgeable about NextGen plans and capable of envisioning the "to be" environment without being overly captive to "as is" thinking. The NCOD approach is to analyze the key elements and relationships in the organization's core information exchanges and to represent them in a formal, standardized model, called an"ontology." As part of the analysis, the COI Engagement Team generally prepares selected Department of Defense (DOD) Architecture Framework (DODAF) products (see Section 4.2 for more information). The COI participants would be responsible for both registering existing services and databases with the potential to become services, and identifying services that NextGen requires, or that would help to facilitate NextGen. If deemed appropriate, the COI participants may also formulate a plan for developing those services that NextGen needs but does not currently have.

- **Agile Development.** NCOD deploys COI Engagement Teams, which are small, cross-functional teams that can rapidly conduct the appropriate analyses to develop the NextGen Enterprise Ontology, which is a compilation of NextGen COI Ontologies. These COI Engagement Teams can respond quickly to changing requirements, making continuous improvements over successive development cycles. The use of COI Engagement Teams is intended to jump start the overall COI development process in an environment where there are disparate stakeholders, a breadth of NextGen requirements, wide-ranging functional knowledge requirements, and varying levels of COI or WG maturity.

- **Ontology driven service generation.** The COI Engagement Teams define key terms first in an ontology language (e.g., RDF/OWL). If messages are needed, then a message schema (in XML, for instance) that is based on the ontology can be created. The ontology provides the single semantic framework that supports the information-sharing needs of a

[4] Concept of Operations for the Next Generation Air Transportation System V3.1

COI within the context of NextGen. All message schemas should tie back to the ontology, so that the ontology provides the means for interpreting information from other agencies or communities that use terms differently. In some cases, services may already exist, and it will be necessary to reverse engineer these services to conform to the ontology-driven service generation approach. This entails, among other things, a mapping from existing schemas to the ontology.

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1.0 Purpose

This document describes the approach used by the Joint Planning and Development Office (JPDO) Net-Centric Operations Division (NCOD) to facilitate the implementation of efficient, sustainable, and reusable inter-organizational information-exchange services within a SSOA. It outlines a typical engagement between an NCOD COI Engagement Team and a NextGen Community of Interest (COI) or working group (WG) and describes the set of products that result from a typical engagement. These products will then be used by the NextGen partner agencies to implement their information exchange services.

For some engagements, the process may be tailored specifically for that engagement. In those cases, the process may vary somewhat from what is described in this document. For example, the Weather WG asked the COI Engagement Team to focus on the As-Is products, so To-Be views were not created for the initial weather engagement. The To-Be views may be created in a future development cycle.

2.0 Introduction

The NextGen initiative was mandated by Congress to modernize the U.S. Air Transportation System in order to increase capacity and reliability, improve safety and security, and minimize the environmental impact of aviation. The required improvements to the air transportation system are to be achieved through space-based navigation, digital communications, layered adaptive security, and net-centric information access for operations.

The mission of the NCOD is to manage policies and strategies for information sharing and to coordinate investment and development of network-enhancing capabilities in support of NextGen. Effective information sharing is crucial to maximizing the value of an organization's information assets, reducing costs through reuse and agile architecture, and leveraging an organization's know-how. While larger and more diverse enterprises create greater information sharing challenges, they also offer considerable benefits.

Some of these information-sharing challenges arise because different groups may use different terminologies to describe the same things, or the same terminology to describe different things. Critical knowledge may remain locked in peoples' heads or buried in application code. Potential synergies can be lost because information remains isolated and disconnected. NCOD and the COI Engagement Teams apply Semantic Web technologies (such as ontologies) to overcome these barriers to information sharing. Key attributes of the net-centric information-sharing environment envisioned for NextGen include:

- Services that are discoverable, accessible, and well-annotated
- Data that are understandable, accurate, and timely
- Published service-level agreements

- Secure and collaborative information-sharing environment[5]

This document outlines a strategy for working with COIs and WGs to identify and provision high-value information-exchange services that will meet these criteria and improve both situational awareness and operational efficiency across NextGen.
JPDO recommends the use of an iterative methodology with respect to interacting with individual COIs. There are a number of NextGen COIs that the COI Engagement Team needs to work with, but the Team's time is limited. Rather than attempting to capture *all* of a particular COI's information elements upfront (which would take a significant amount of time during which other COIs would be waiting), the COI and the COI Engagement Team select a few high-payoff information exchanges to focus on for the first round and build out the ontology for those information exchanges. Once that iteration is completed, there is typically a period of time where the COI is evaluating and vetting the results of that iteration within the COI to determine what, if any, revisions need to be made to the ontology. While the COI is vetting the ontology, the COI Engagement Team moves on to work with a different NextGen COI. When the COI Engagement Team returns to work with the first COI for the second iteration, they address any necessary revisions, and then move on to analyze the next set of high-payoff information exchanges. Through this iterative process, with each additional iteration for a COI, the COI ontology (and by extension, the NextGen Enterprise Ontology) becomes more comprehensive.

2.1 Ontology-based Information Services

The COI Engagement focuses on an analysis of the information exchanges that are central to an organization's business or mission. The COI Engagement Team will work with the COI's Subject Matter Experts (SMEs) to identify those information exchanges. The COI Engagement Team will then either reuse an existing COI domain ontology[6] by registering the ontology in the NextGen Service Metadata Catalog, or if a domain ontology does not exist, the COI Engagement Team will work to produce and register an ontology. The ontology will then be aligned with the NextGen Enterprise Ontology.[7] When fully completed, the ontology will represent a comprehensive set of information about the attributes of the objects and operational activities that are important to the COI as a whole. Since the COI Engagement Teams are following an iterative schedule, they are building the COI ontologies incrementally through repeated iterations with each COI. This development methodology focuses on working with the high-payoff information exchanges first, but also means that the early versions of the COI ontologies will not be all-encompassing.

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[5] Department of Defense Net-Centric Data Strategy, May 9, 2003.
[6] An ontology is a formal, machine-readable representation, or model that associates an organization's data elements with the real-world entities.
[7] Note that the detailed procedures for how an element goes from the COI domain ontology to the NextGen Enterprise Ontology still need to be worked out.

A COI domain ontology is a structured representation of the types of entities and relations existing within a given domain that is designed to support exchange and reuse of data and information. It is not intended to be a highly-specific data/information model that is tied to a particular type of implementation. The COI domain ontology describes how things are in the world, but not how they are used or constrained within a closed information system. This means that different information systems can use the same ontology to describe the meaning of their data without having to harmonize and deconflict the syntax of each other's information models. For instance, the Weather COI domain ontology contains elements such as wind speed, wind direction, and cloud type. It assigns a definition and Universal Resource Identifier (URI) to each element, but it does not assign datatypes (which may be platform-specific) to them, as one would in a data/information model. This lack of specificity to a particular type of implementation is what makes ontologies useful tools for understanding and using heterogeneous datasets.

One of the advantages of the ontology is that it can be both human and machine-readable. Another advantage of the ontology is that it does not make any rigid commitments with respect to syntax but rather can accommodate a variety of implementation platforms. Consequently, the ontology provides support for service discovery capabilities that are not tied to any particular programming language or database management system, and that enable potential information consumers to search for appropriate data resources even if they are not familiar with the particular linguistic conventions of the service provider. An example may clarify how the ontology performs this function. Let's say that you are interested in finding all services across multiple agencies that have some relationship to the term "dog," which is the term that is used in your agency. Some of the other agencies, however, may use the term "canine." A simple keyword search would not include the services from those agencies in your result set because they don't use the term "dog." But if you have an ontology that defines "canine" as the equivalent of "dog," an ontologically-aware search will return services that use either term. This is how an ontology enhances the discovery of services. Likewise, an ontology can filter out unwanted results, such as "hot dog" which is not semantically related to "dog."

2.2 Describing and Provisioning[8] Information Services

The COI engagement process focuses on the identification of information exchanges. In some cases, these will be existing information exchanges that are already represented in services. In other cases, these will be information exchanges that have been identified as necessary or helpful for NextGen implementation even though they do not currently exist.

For those cases where there is an existing service, the information exchanges may be provisioned at one of three levels as described below.

[8] Provisioning refers to providing and registering metadata and other explanatory material about a service in conjunction with registering that service for reuse.

Level I – Create Service Metadata Card

In order to register a service in the NextGen Semantic Metadata Catalog, one must complete a Service Metadata Record. The Service Metadata Record contains the following metadata elements[9]:

dc[10]:contributor
dc:coverage
dc:creator
dc:date
dc:description
dc:format
dc:identifier
dc:language
dc:publisher
dc:relation
dc:rights
dc:source
dc:subject
dc:title
dc:type
foaf[11]:primaryTopic
icism[12]:classification
meta[13]:pointOfContact

Level I provisioning is mandatory for registration in the NextGen Semantic Metadata Catalog, and is intended to allow external participants to register their services even if they have not gone through the COI Engagement process, which results in a fully-provisioned service. The Semantic Metadata Portal would provide this functionality. As for the detailed elements, at this time no decision has been made with respect to which metadata elements are mandatory and which are optional. Also, additional artifact specific metadata elements may be added as needed.

[9] Note that some of these metadata elements will be mandatory and some will be optional. Detailed decisions about which will be mandatory or optional have not yet been made.
[10] The "dc" prefix identifies a data element as part of the Dublin Core metadata set, a small group of fundamental elements that can describe and catalog most resources.
[11] The "foaf" prefix identifies a data element as part of the "Friend of a Friend" ontology that describes people, their activities, and their relationships to other people and objects.
[12] The "icism" prefix identifies a data element as part of the Intelligence Community Information Security Marking Metadata set.
[13] The "meta" prefix identifies a data element that was created for the NextGen Enterprise Ontology.

Level II - Semantic Provisioning

A semantically-provisioned service is one that is registered in the NextGen Semantic Metadata Catalog (as described for Level I Provisioning above). In addition, Level II Provisioning generally includes:

- A mapping from message data elements (e.g. XML schema components) to ontology elements in the NextGen Enterprise Ontology. (These mappings are currently done through the use of semantic tags[14])
- A representation of the service using one or more of the following service ontologies[15]:
    - Minimal Service Model (MSM)
    - Semantic Annotations for WSDL and XML Schema (SAWSDL)
    - Web Service Modeling Ontology Lite (WSMO-Lite)
    - HTTP Vocabulary

Level III – Operation and System Provisioning (e.g. Full Provisioning)

A fully-provisioned service must also include supporting documentation about the following aspects of the service:

- Documented performance characteristics and delivery infrastructure
- Documented cyber-security considerations
- Documented business rules governing the exchange of information, such as Quality of Service (QoS) constraints
- Selected Department of Department of Defense Architecture Framework (DODAF) products, including:
    - The Operational View-5 (OV-5): The Operational Activity Model depicts the operations that are normally conducted in the course of achieving a mission or business goal.
    - The OV-2: Operational Node Connectivity Description identifies the key players and interactions necessary to conduct the corresponding operational activities.
    - The OV-3: Operational Information Exchange Matrix describes the information exchanged and the relevant attributes of the exchanges.

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[14] A semantic tag is an XML tag that adheres to a specific format and provides a way to annotate an ontology or other resource with metadata. Semantic tags can be used to map separate XML Schemas to each other.

[15] These service ontologies have been developed collaboratively by working groups, usually associated with a standards body such as the W3C. They are not part of the NextGen enterprise ontology, but they may be used in conjunction with it.

When existing services are fully-provisioned, that improves system interoperability and helps to ensure that the services are discoverable, understandable, and usable as intended, even by unanticipated users.

In those cases where information exchanges do not currently exist but have been identified as necessary or helpful for NextGen implementation, although the services cannot be fully provisioned as described above, it is still important to describe them and to register those descriptions. For such services, the Level I Provisioning described above (Service Metadata Card) should still be completed, to the extent possible, because this information will be used in searches to find the planned information exchanges. The rest of the material registered should focus on the content of the information exchange. This could include ontology elements and/or selected DoDAF views such as the OV-5 (Operational Activity Model) and/or OV-3 (Operational Information Exchange Matrix).

2.3 COI Engagement Teams

The COI Engagement Team is an agile development team that can rapidly develop the products listed above, respond quickly to changing requirements, and make continuous improvements over successive development cycles. NextGen stakeholders comprise a diverse community, with widely disparate requirements, no centralized authority, and varying levels of COI or WG maturity. The use of COI Engagement Teams is intended to overcome some of these challenges by implementing a coordinated process for developing a net-centric information exchange environment in NextGen.

A COI Engagement Team consists of permanent members and adjunct members. The permanent members typically come from JPDO, are officially assigned to the team, and can be assigned official tasks. On the other hand, adjunct members typically come from the COI and/or JPDO study teams, are not officially assigned to the team, and therefore cannot be assigned taskings but rather augment the team in order to provide critical skills, expertise and insight. The adjunct members include subject matter experts (SMEs), partner agency personnel and others. As such, each COI Engagement Team is a unique, cross-functional team composed of specialists, each of whom brings a unique set of skills and expertise to bear on the shared goal of developing and provisioning information exchange services. COI Engagement Team member roles include the following:

Team Lead	Facilitates and leads the analysis of the COI's information exchanges.
Ontologist	Develops ontologies and provides technical expertise for associating the real-world concepts and their relations with the corresponding components of other agencies or COIs.

Business Architect	Documents the operational and systems architecture relevant to the selected COI information exchanges with a view towards ensuring that the business and information technology are in sync. The Business Architect ties the COI-level operational and systems architecture to the JPDO Enterprise Architecture.

2.4 COI Engagement Team Responsibilities

The NCOD COI Engagement Team will analyze information exchanges for the purpose of developing or compiling the NextGen Enterprise Ontology. The development of the ontology is part of Level II Semantic Provisioning, as shown in Figure 1, below. If a COI or partner agency has an existing ontology, the NCOD COI Engagement Team will make every effort to use that ontology in the NextGen Enterprise Ontology. If the existing ontology is lacking definitions or other key semantic information, the COI Engagement Team will work with the COI to develop them. If there are multiple competing ontologies, the COI Engagement Team will work with the COI to select one or a subset of multiple ontologies for the COI ontology. Note that the COI ontology cannot contain competing or duplicative ontologies, however the competing ontologies can be mapped to each other so that whichever ontology someone is using, they can still use materials based on the other ontology.

The NCOD COI Engagement Team will also identify and provision existing information exchange services for reuse by the NextGen community. Identifying and provisioning existing services provides immediate business value by allowing the JPDO to quickly improve data accessibility for a wide range of NextGen stakeholders. This approach leverages capabilities already in place, helps to ensure reuse of services, identifies the gaps between existing capabilities and the information exchange requirements captured through operational activity analysis and modeling. These analyses also enable the COI Engagement Teams to develop the information exchange architecture products necessary to understand and provision existing systems or to support the creation of new services. The provisioning of services is part of the Level II and III Provisioning, as shown in Figure 1, below.

3.0 Overview of COI Engagement Process

Prior to starting a COI engagement, the COI Engagement Team works with NCOD leadership to identify a COI Lead, draft and execute a COI Project Charter, perform background research to identify important domain objects (people, places, and things), processes, operational activities, and candidate information exchanges. Once a COI Lead has been identified and a COI Project Charter has been executed, the COI Engagement Team works with the COI Lead to prioritize information exchanges to be analyzed, and to identify business and technical SMEs.

Note that in some cases, if a COI Lead cannot be identified in a timely fashion, NCOD may

choose to exercise one of the following options as a contingency:

1. Postpone the engagement with that COI until a COI Lead is identified

2. Assign a government employee to serve as a proxy for the COI Lead

In keeping with the iterative methodology, the COI Lead and/or COI SMEs select a few key information exchanges as the focus for each engagement. The COI Engagement team then reviews the JPDO Enterprise Architecture (EA) in order to identify elements that are related to the selected information exchanges. The team will re-use or reference those elements in their work, as appropriate. In many cases, even where they deal with the same or similar subject matter, there will be a difference in granularity between the JPDO EA and the COI Engagement Team's work, i.e. the JPDO EA may deal with something at a high level (overview), and the COI Engagement Team may be working at a lower level of detail.

Prior to engaging with SMEs, the COI Engagement Team prepares a list of questions designed to elicit expert knowledge from them about the information exchanges that have been selected for the engagement. The COI Engagement Team also gathers information about the existing and required infrastructure for data communications and cyber security.

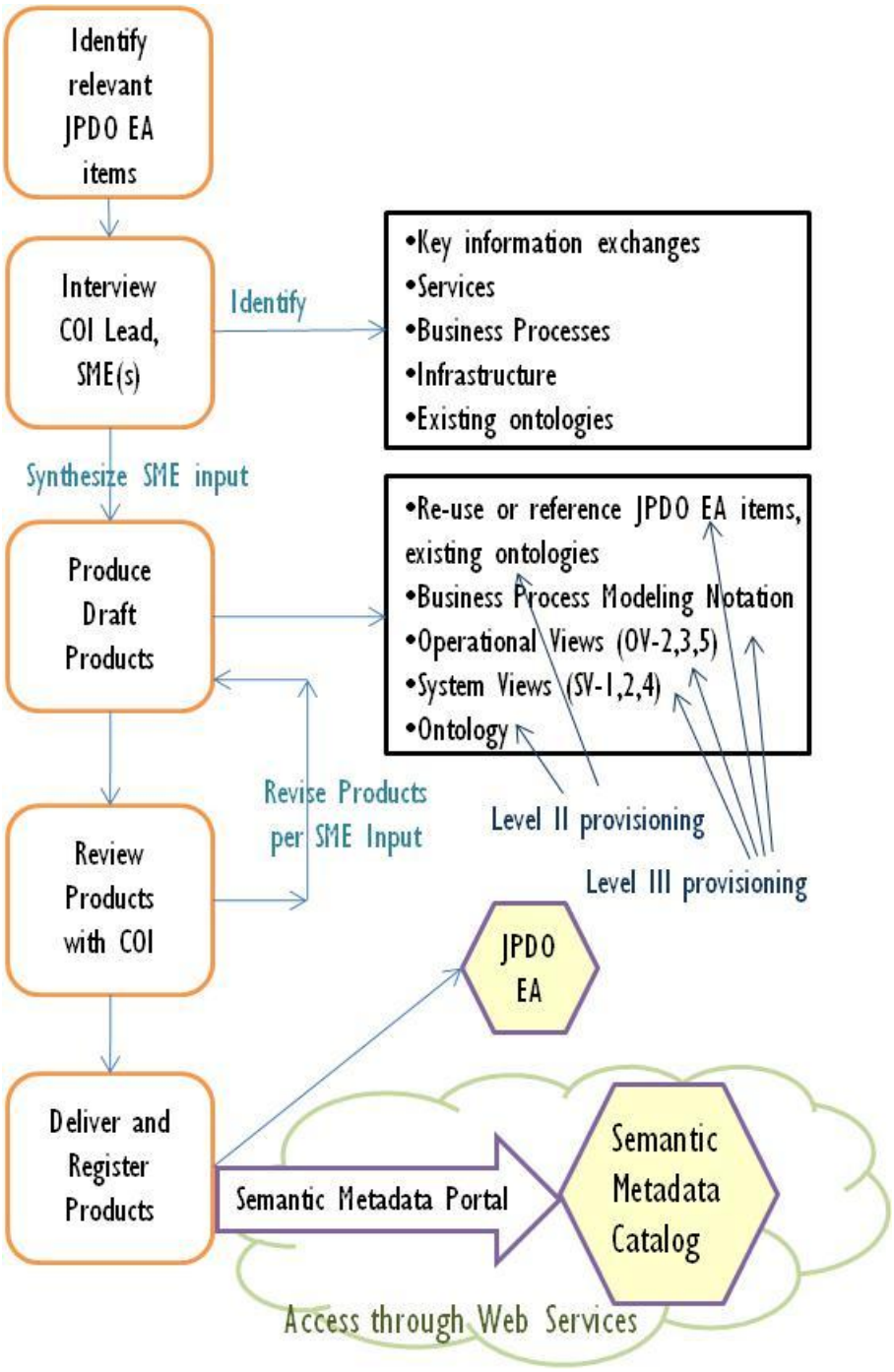

Figure 1: COI Engagement Overview

As depicted in Figure 1, after reviewing the JPDO EA and completing other preparatory research, the COI Engagement Team interviews the COI Lead and SMEs. As a general rule, the entire COI Engagement Team will participate in the SME interviews. The rationale for this is that each team member brings a different set of skills and expertise to the team, so it is important for each of them to interact directly with each SME. As the COI Engagement Team interviews SMEs, it analyzes the results of the interviews and synthesizes the SME inputs, together with the relevant items from the JPDO EA, into a set of information exchange architecture and ontology products that describe the information exchange(s). These products are described in Section 5 "Review of COI Engagement Products." As the team continues to interview additional SMEs, the products evolve to incorporate the additional feedback. In general, as the COI Engagement Team constructs draft information exchange architecture diagrams, ontologies, or other products, they review them iteratively with selected SMEs and/or the COI Lead in order to ensure that the products are accurate and complete. When the NextGen Enterprise Ontology and any message transformations[16] have passed internal testing and been reviewed with the COI, the COI Engagement Team uses the Semantic Metadata Portal[17] to update the Semantic Metadata Catalog with the latest versions of the NextGen Enterprise Ontology and message transformations.

4.0 Technical Approach[18]

The COI Engagement Team engagement will adhere to established standards and best practices. These include the following:

- *Air Force Community of Interest (COI) Primer 1.0* (dated 12 July 2011), which addresses production of requirements for service acquisition and implementation, as well as production of common vocabularies

- *DOD Net-Centric Data Strategy* (dated 9 May 2003) and *Net-Centric Service Strategy* (dated 4 May 2007), which provide guidelines for information sharing, ontology development, and implementation of data services

- *DOD Architecture Framework (DODAF)*[19], an Enterprise Architecture reference model

[16] A message transformation defines a method to permit systems with incompatible data formats to share data. Message transformations are often done with XML Stylesheet Language Transformation (XSLT) files.
[17] The Semantic Metadata Portal is a web interface through which users can access the Semantic Metadata Catalog. With the appropriate access controls, it allows one to view materials that have been registered in the Semantic Metadata Catalog, or to register items in the Semantic Metadata Catalog, if appropriate. Both the Semantic Metadata Portal and the Semantic Metadata Catalog are discussed in greater detail in Section 6.1 Semantic Metadata Catalog and Portal.
[18] The COI Engagement Plan specifically uses a DoD net-centric approach as DoD approach is mature and well understood.
[19] The COI Engagement Team will coordinate with the NextGen Enterprise Architecture Team regarding DODAF version 1.5 vs. 2.0.

- *Web Ontology Language (OWL)* [published by the World Wide Web Consortium (W3C)], which provides a standard top-level ontology and a framework for developing the enterprise and domain-specific ontologies that will facilitate use of NextGen data services

4.1 Ontology

The NextGen Enterprise Ontology serves as a shared model that sets forth the precise nature of the data elements (such as people, places, things and activities) about which NextGen COIs exchange information. The ontology focuses on meaning or semantics. Thus, it provides an excellent mechanism for semantically associating (in a machine-readable format) the data elements of different COIs where data elements have different names but refer to the same thing. For example, the atmospheric phenomenon that is sometimes referred to as the "aurora borealis" is also known as the "northern lights." Regardless of which term is used, the phenomenon referred to is the same. In other words, different communities may use the same word to describe different things. An ontology representing the phenomenon will contain only one representation of the phenomenon itself, but that representation may be associated with multiple data services which use different data element names to refer to it. Data providers need only map their data elements to the appropriate concept in the ontology once, but by doing so, will thereby effectively map their own data elements to any other semantically identical data elements that have also been associated with the NextGen Enterprise Ontology. A similar semantic issue occurs when different COIs use the same term to mean different things (e.g. "mercury" as an element or as a car). Perhaps in one ontology, "mercury" is defined as an element, and in the other ontology "element mercury" is defined as the element, while "mercury" is defined as a type of car. In this case, one would map "mercury" from the first ontology to "element mercury" from the second ontology.

In some cases, the COI and/or NextGen partner agencies may have already developed a domain ontology in which its domain objects are represented. In such cases, the COI Engagement Team will work with the COI or partner agency to register the ontology in the NextGen Semantic Metadata Catalog and to align the COI's or partner agency's ontology with the NextGen Enterprise Ontology. In cases where there is no domain ontology, and the domain objects and operational activities are not already part of the NextGen Enterprise Ontology, the team will extend the NextGen Enterprise Ontology to include them.

4.2 DODAF Products

The COI Engagement Team develops the information exchange architecture using DODAF views to illustrate the information exchanges identified through the analysis. The high-priority domain objects and processes identified by the COI Lead serve as the starting point for the COI Engagement Team's analysis. For example, in the Weather COI, a meteorological report from a weather sensor and a pilot's observation report might be selected as key information exchanges. The COI Engagement Team then analyzes these information exchanges through documentation

and successive interviews with SMEs. Based on this analysis, the team develops appropriate DODAF products which describe the type of information exchanged and the technical requirements – latency, service levels, etc. – for these exchanges.

5.0 Review of COI Engagement Products[20]

Figure 2 displays the COI Engagement products that result from the synthesis work described in Section 3 and shows how those products relate to each other. Each product is depicted by a rectangular box, and the arrows roughly indicate dependencies among the products. Upon approval by the JPDO approval process[21], all of the Engagement Products are registered (as described in Section 6.0 Registration of Products") in the Semantic Metadata Catalog and integrated into the JPDO EA. The following sections provide a brief explanation of the products that result from a typical COI engagement.

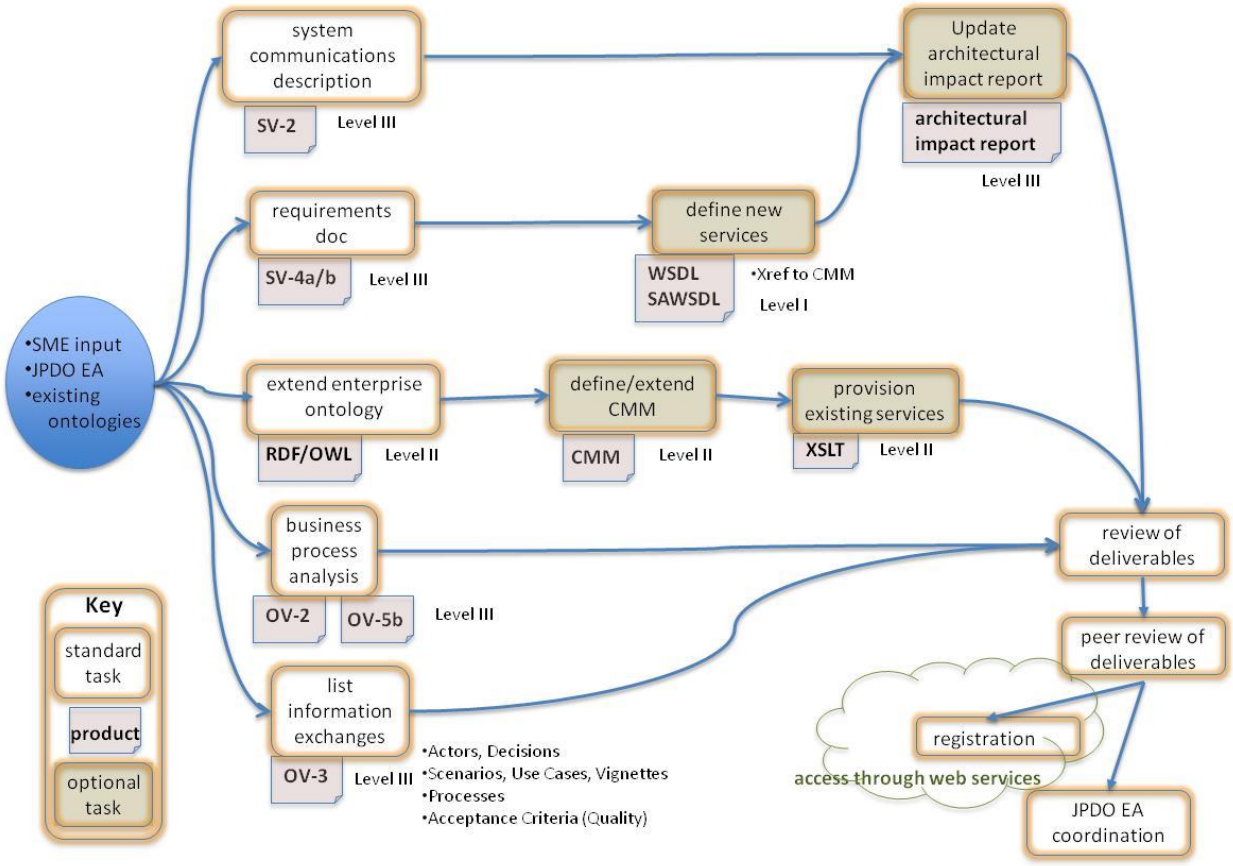

Figure 2: Overview of COI Engagement Products

[20] The COI products will be developed in conjunction with the NextGen Chief Architecture and the relevant NextGen partners.
[21] The relevant JPDO approval process will be used to approve existing products for use with NextGen.

5.1 Documentation of Business Processes

The COI Engagement Team begins with the relevant artifacts from the JPDO EA and input from Subject Matter Experts (SMEs), as shown in the far left of Figure 2. The team may prepare a Business Process Model Notation (BPMN)[22] diagram up front if the team believes that such a diagram will be a useful tool that will assist them in preparing the DODAF operational views.

The Operational Activity Model (OV-5), which is part of the business process analysis as shown in Figure 2, describes the operations that are normally conducted in the course of achieving a mission or a business goal. It describes capabilities, operational activities (or tasks), input and output (I/O) flows between activities, and I/O flows to/from activities that are outside the scope of the architecture. The OV-5 is based on existing documentation and/or SME input.

The Operational Resource Flow Description (OV-2), which is also part of the business process analysis as shown in Figure 2, depicts Operational Needlines[23] that indicate a need to exchange resources (e.g., information, funding, personnel, or materiel). The main features of this product are the operational nodes and the needlines between them that indicate a need to exchange information. The product indicates the key players and the interactions necessary to conduct the corresponding operational activities of the OV-5. The selection of information exchanges drives which operational activities will be documented.

5.2 Documentation of Information Exchanges

The COI Engagement Team will typically document the information exchanged along with the relevant attributes of the exchanges in the form of a DODAF OV-3– Operational Resource Flow Matrix, shown as part of the activity to list information exchanges in Figure 2. The OV-3 identifies the resource transfers that are necessary to support operations to achieve a specific operational task. The OV-3 details Resource Flow exchanges by identifying which Operational Activity and locations exchange what resources, with whom, why the resource is necessary, and the key attributes of the associated resources. The OV-3 identifies resource elements and relevant attributes of the Resource Flows. It then identifies the Operational Activities in which those Resource Flows participate, whether as the information producer or consumer. More specifically, the OV-3 associates the Resource Flows with the particular Needlines that they satisfy for the Operational Activity.

5.3 Documentation of Systems Communications and Requirements

The Business Architect is responsible for documenting existing services. The required level of detail for the documentation is based on the business needs, the availability and quality of system

[22] Business Process Modeling Notation (BPMN) is a method of illustrating business processes in the form of a diagram similar to a flowchart. It is not a DoDAF product, but because it encapsulates the information from a few DoDAF products, it can be helpful in preparing those DoDAF products.
[23] In DODAF, a needline represents an information exchange or communication between two operational nodes. An operational node is an entity that produces, consumes, or manipulates information.

documentation, and the availability of knowledgeable SMEs. In general, the COI Engagement Team will:

- Obtain and review system documentation
- Interview knowledgeable SMEs
- Develop system architecture products necessary to understand and provision existing systems
- Validate system architecture products with SMEs
- Compile and deliver system architecture products

The COI Engagement Team will leverage existing system documentation as much as possible. In many cases, system documentation alone may not provide a complete and accurate picture of the existing system capabilities. In such cases, the system documentation will guide the interview process by providing background information and helping the team develop targeted questions to obtain more information or to seek clarifications from technology SMEs. In general, the following DODAF products are developed during the analysis of existing systems:

- Systems Interface Descriptions (Systems View-1) (SV-1)
- Systems Communications Description (SV-2)
- Systems Functionality Description (SV-4)

The SV-1 addresses the composition and interaction of systems. System interface descriptions link together the operational and systems architecture models by depicting how resources are structured and interact to realize the logical architecture specified in an operational resource flow description. The SV-2, shown as the systems communication description in Figure 2, specifies the system resource flows between systems and the protocol stacks used in connections. A key element of the SV-2 is the documentation of cyber security requirements that enable secure information exchanges. The SV-4, shown as the requirements document in Figure 2, specifies the functionality of resources in the system architecture, including functional resources, systems, performer and capabilities.

5.4 Extensions to the NextGen Enterprise Ontology

Described at a high level in Section 2.1, the NextGen Enterprise Ontology is the overarching ontology that includes all the COI ontologies that have been vetted through the NCOD COI Engagement Team process. In addition, it may include high-level ontologies such as an upper-level ontology[24] that help to organize the COI-specific content in a consistent and reusable manner. It is depicted as part of Level III provisioning in Figure 2. The primary inputs into the Enterprise Ontology for each COI engagement are the elements from each information exchange.

[24] An upper-level ontology is an ontology which describes very general concepts that are the same across all knowledge domains. The most important function of an upper ontology is to support very broad semantic interoperability.

These are identified in 1) the information exchange elements in OV-3 Operation Resource Flow Matrix and 2) the data elements from existing information exchange services. These elements represent an initial set of terms to be defined in and incorporated into the NextGen Enterprise Ontology.

The COI Engagement Team gives each element in the NextGen Enterprise Ontology a logical definition, rigorously utilizing the structure of the taxonomy in the formulation of its definitions when possible. Each logical definition is associated with an authoritative source from which the definition is derived. The authoritative source may be a doctrinal source or a SME. Where possible, the team will use existing ontologies in order to define the semantics of an information exchange element. The use of existing ontologies is intended to improve semantic interoperability. For example, the ISO-3166 standard is widely used to refer to geographic regions around the world. By re-using ISO-3166, references to countries by the COI will be understandable by the many other agencies that use ISO-3166. Once the information objects and their attributes have been defined in the NextGen Enterprise Ontology, the extensions are validated for content and consistency.[25]

The NextGen Enterprise Ontology can be used as the basis for message schemas, and in fact, doing this ensures that the message schemas are consistent with the semantics of the ontology.

5.5 Identify Service Gaps

The COI Engagement Team may, based upon COI need, provide a high-level description of services that are needed by the community. These service gaps would be identified by comparing the Information Exchange Requirements in the OV-3 with the COI's existing services. Note that in some cases, the community may already have identified these gaps. In that case, this step of the process may be skipped.

5.6 Provision Existing Services

In cases where there are existing web services, two additional artifacts are produced:

1) Message transformations that tie the web services' native message schemas to the NextGen Enterprise Ontology. This is generally done with an eXtensible Stylesheet Language Transformation (XSLT)

2) A Service Ontology defined to support service discoverability, understandability, and interoperability. This is accomplished by representing services within an ontology and annotating these representations with content from the NextGen Enterprise Ontology using Semantic Annotations for WSDL and XML Schema (SAWSDL)

[25] These steps represent the technical validation, or testing, of the Ontology. The content of the ontology is validated through the COI, WG, and/or SMEs.

6.0 Registration of Products

6.1 Semantic Metadata Catalog and Portal[26]

A Semantic Metadata Catalog and Portal will be created to support the cataloging and reuse of services.[27] The Semantic Metadata Catalog is federated with agency service registries and thus provides a single source for discovering products. It stores metadata about products and points to where they are stored. The Semantic Metadata Portal is a web-based portal that allows users access to the Semantic Metadata Catalog to view, add, or update catalog records. The following products (if they exist) will be registered in the Semantic Metadata Catalog and Portal[28]:

- A catalog of documented services
- WSDL files for documented services and newly defined services
- SAWSDL documents containing semantic annotations that link to the NextGen Enterprise Ontology.
- XSD documents that contain the message schemas based on the NextGen Enterprise or Domain Ontology
- RDF/OWL document that contains the NextGen Enterprise or Domain Ontology
- OV-2, OV-3, and OV-5
- SV-1, SV-2, and SV-4
- All View 2 (AV-2) Integrated Dictionary
- Service Memorandum of Agreement (MOA)

7.0 COI Engagement Phases

Based on JPDO plans for engaging with JPDO communities, the following represents the phased order in which the COI Engagement Teams tentatively plan to engage the various JPDO COIs or working groups. This schedule is subject to change as needed to support JPDO plans.

Phase 1

- Weather
- Integrated Surveillance

Phase 2

- Unmanned Aircraft Systems

[26] Products within the Semantic Metadata Catalog and Portal will be referenced/listed in the NextGen Enterprise Architecture and will also be referenced in the Joint Planning Environment. Any updated to these products will be managed via the NextGen Configuration Management (CM) process.
[27] At this point, it has not been decided who will create and/or own the Semantic Metadata Catalog and Portal.
[28] These products will be coordinated with the JPDO Enterprise Architecture Team.

Phase 3

- Flight & Flow
- Airport Business and Operations
- Safety
- Trajectory and Performance-Based Operations
- Layered Adaptive Security
- Environmental Management
- Positioning, Navigation, and Timing
- Airline Business and Operations
- Special Use Airspace

8.0 Post COI Engagement Lessons Learned and Refinement

At the end of each COI Engagement, the team will conduct a post-engagement lessons learned activity. This activity is essential to refine the engagement process to better serve the COI Engagement Team and community with a more efficient and effective engagement process. The goal is to capture lessons learned from the post-engagement while they are still fresh in peoples' minds. The results are summarized and recommendations are passed on to future teams. The lessons learned are also used to refine the overall engagement process.

If the COI Engagement Team, through the course of the engagement, identifies any necessary changes to the COI Engagement Process as described in this document, the team will also update this document at the end of the COI engagement.

9.0 Glossary

Agile Development	A development process based on iterations where requirements and solutions evolve through collaboration between self-organizing cross-functional teams.
Authoritative Data Source	A data source, potentially identified by the COI Engagement Team, that is designated by a COI and/or SMEs as providing authoritative data and/or definitions.
Business Architect	An architect who documents the operational and systems architecture relevant to the COI with a view towards ensuring that the business and information technology are in sync. Ties the COI-level operational and systems architecture to the JPDO Enterprise Architecture.
Business Process	A structured collection of tasks that produces a service or product.
Community of Interest (COI)	A community of people who share common data and/or services.
COI Engagement Team	A group composed of a Team Lead, an Ontologist, and a Business Architect. This group is formed to produce the products necessary to provision a new or existing service based on information objects.
Concept	A defined term used in a business model.
Enterprise Architecture	A rigorous description of the structure of an enterprise, its decomposition into subsystems, the relationships between the subsystems, the relationships with the external environment, the terminology to use, and the guiding principles for the design and evolution of an enterprise.
Information Exchange	A description of a kind of message used in a business process, combined with other information such as the service contract.

Information Element	An object (or term) that is used in one or more information exchanges in order to convey facts about a real-world entity such as a person, aircraft or weather phenomenon.
Infrastructure Specification	A description of the logical or physical systems of a business.
Net-Centric Operations Division	A division of the Joint Planning Development Office tasked with supporting information sharing amongst communities of interest via semantic service-oriented architecture.
Ontologist	A technical expert who builds models of real-world concepts, their terms, and their meanings.
Ontology	A formal representation of the knowledge within a domain by a set of concepts and the relationships between those concepts.
Policy	A recommendation or mandate to implement a particular technical standard.
Semantics	The interpretation of the meaning of terms in a particular context.
Service Contract	The formalization of the participants and the rules of engagement for collaboration.
Taxonomy	The set of classes in an ontology and their relationships according to the subclass relation.
Team Lead	A technical expert who facilitates and leads the analysis of the COI's information exchanges.
Technical Standard	A controlled artifact maintained by a standards body.
Upper-level Ontology	An ontology which describes very general concepts that are the same across all knowledge domains. The most important function of an upper ontology is to support very broad semantic interoperability.
Web Ontology Language (OWL)	A family of knowledge representation languages used for authoring ontologies.

Working Group	A multi-agency collaboration focused on information sharing in a particular domain.

10. Acronyms

BPMN	Business Process Modeling Notation
COI	Community of Interest
DOD	Department of Defense
DODAF	DOD Architecture Framework
EA	Enterprise Architecture
I/O	Input/Output
JPDO	Joint Planning and Development Office
MOA	Memorandum of Agreement
MSM	Minimum Service Model
NCOD	Net-Centric Operations Division
NETE	Net-Enabled Test Environment
NextGen	Next Generation Air Transportation System
OV	Operational View (DODAF)
OWL	Web Ontology Language
QoS	Quality of Service
RDF	Resource Description Framework
RDFS	Resource Description Framework Schema
SAWSDL	Semantic Annotations for WSDL and XML Schema
SME	Subject Matter Expert
SLA	Service Level Agreement
SV	Systems View (DODAF)
XSLT	eXtensible Stylesheet Language Transformation
WG	Working Groups
WSDL	Web Services Description Language
WSMO	Web Service Modeling Ontology
WS-Policy	Web Services Policy
XML	eXtensible Markup Language